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ABSTRACT

A visual rhythm-intonation-duration display called Instantaneous Pitch-period Indicator (Amplitude-Intonation, Duration) (IPPI-AID) was used in several classrooms in a school for the deaf to determine its usefulness as an electromechanical aid for classroom language instruction with speech/language materials. It was found in all classroom levels, from early childhood education to junior high school, that the IPPI-AID motivated the children to increase both quality and variety of their vocalizations. Teacher and student response was enthusiastic. Classroom materials derived from pre-planned speech/language lessons were more effective than expressions developed from spontaneous language activities. Spoken expressions using mostly voiced speech sounds, and permitting prolonged phonations in stressed syllables and words, produced the clearest oscilloscope traces and most discernible rhythm and intonation patterns. Corrective individual instruction during group classroom use was not effective, indicating the need for separate individual instruction for selected children experiencing difficulty learning intensity, rhythm, or intonation aspects of spoken language. Occasional equipment malfunctions indicated the need for a constant availability of engineering assistance for periodic checks, adjustments and redesign of certain parts of the equipment. (Author)

ABSTRACT

A visual rhythm-intonation-duration display called IPPI-AID* was used in several classrooms in a school for the deaf to determine its usefulness as an additional aid for classroom instruction with speech/language materials. It was found in all classroom levels, from nursery (pre-school age) to upper school, that the IPPI-AID motivated the children to increase both the quality and variety of their vocalizations.

Teachers were able to learn to operate the equipment. Teacher and student response was enthusiastic, although it must be pointed out that teachers volunteered to use the equipment. Other teachers expressed no interest in having the equipment in their classrooms.

Classroom materials derived from pre-planned speech/language lessons were more effective than expressions developed from spontaneous language activities. Spoken expressions using mostly voiced speech sounds, and permitting prolonged phonations in stressed syllables and words, produced the clearest oscilloscope traces and most discernable rhythm and intonation patterns.

Corrective individual instruction during group classroom use was not effective indicating the need for separate individual instruction for selected children experiencing difficulty learning intensity, rhythm or intonation aspects of spoken language.

Occasional equipment malfunctions indicated the need for a constant availability of engineering assistance for periodic checks, adjustments and redesign of certain parts of the equipment.

*Instantaneous Pitch-period Indicator (Amplitude-Intonation, Duration).

Final Report

Project No. 312139
Grant No. OEG-0-9-312139-4094/032/

DEMONSTRATION OF THE INSTANTANEOUS PITCH PERIOD INDICATOR IN CLASSROOMS OF DEAF CHILDREN

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PREFACE

The researchers express their appreciation for the cooperation of the administration, the teachers and the students of the Horace Mann School for the Deaf; we would especially like to mention Miss Eileen Connolly, Principal, and teachers, Miss Ruth Sullivan, Miss Rose Ann Atkin, Miss Mary Deveney and Mr. Louis Bianchi who used the IPPI-AID equipment in their classrooms.

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I. INTRODUCTION

Previous research studies [3, 4, 2] have demonstrated that deaf individuals could improve rhythm and intonation patterns of speech during training which utilized the IPPI-AID* as a visual display for self-monitoring. Similar results were found by Pronovost et al. [5] using the Voice Visualizer for self-monitoring of the articulation of vowels and consonant sounds of speech. These studies used individual instruction of deaf subjects, with a research teacher of the deaf operating the visual feedback equipment. Improvements of specific parameters of speech occurred during relatively short training periods, two to six weeks; teaching materials and programs specifically designed for the capabilities of the equipment were used.

As a result of the success with the use of visual self-monitoring equipment in individual instruction, the question arose how the equipment might be used in a classroom. "Will classroom teachers of deaf children be able and willing to use the equipment producing visible displays of certain parameters of speech?" "Can the equipment be utilized for group instruction?" "How will deaf children respond to the visible speech equipment in classroom situations?"

As an effort to obtain answers to these questions, this demonstration project was concerned with a description of the use of the IPPI-AID in classrooms of deaf children enrolled in a day school for the deaf.

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*Instantaneous Pitch-Period Indicator-Amplitude, Intonation, Duration

II. PROCEDURES

A. The Instantaneous Pitch-period Indica[illegible]

The IPPI-AID provides visual displays of rhythm, intonation and intensity parameters of speech. Figures 1 and 2 illustrate the front of the unit. Rhythm and intonation patterns are displayed on a variable-persistence oscilloscope screen. Intensity is displayed by means of a vertical column of lights (see Fig. 1).

This intensity display on the panel was designed to provide four lights so that only the bottom light will respond to whispers; for normal speaking voice intensity, the lower two or three lights will light up; during conversational levels of speech, variations in intensity will cause variations in lighting the lower two or three lights. The top light responds only to excessively loud sounds. Thus the intensity lights can be used for instantaneous displays and feedback of vocal intensity for whisper, normal and loud intensity levels. This display is also used for vocal training prior to the use of the pitch-duration displays. An intensity level which energizes at least two intensity lights is required to trigger the pitch-duration displays on the oscilloscope screen. The intensity display switch (2) permits the intensity lights to be used without the pitch-duration display, simultaneously with the pitch-duration display, or to be turned off while the pitch-duration display is used.

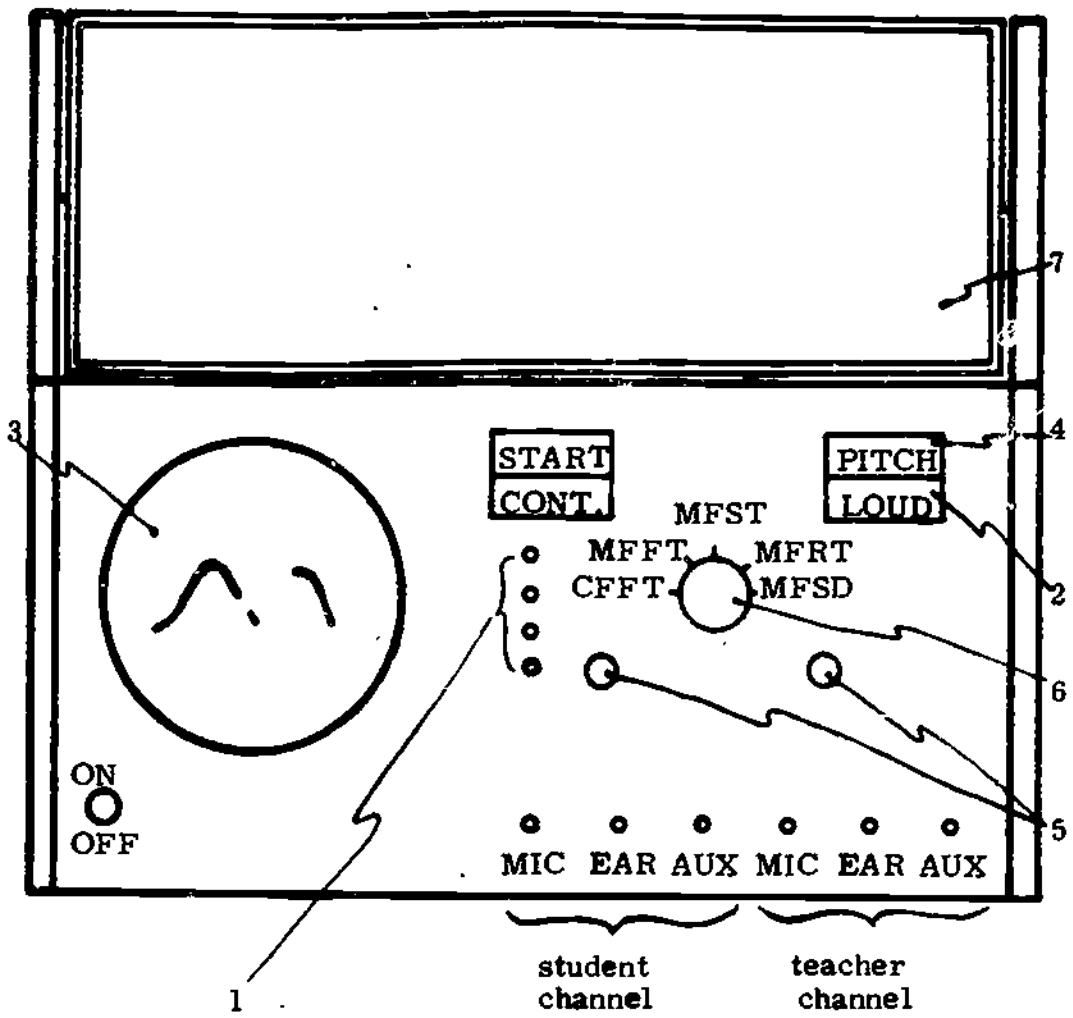
Pitch and duration are displayed as variations in the shape of a line appearing on the storage oscilloscope screen. The oscilloscope used is the Hewlett-Packard 141A, a variable persistence oscilloscope [7], whose plug-in unit contains the IPPI-AID circuits instead of the standard sweep and amplifier unit. The duration of the phonations is displayed along the horizontal axis, with the trace appearing only during voiced phonations. Unvoiced consonants do not produce a trace on the screen. Pitch levels or pitch contours are displayed vertically. In Fig. 3 pitch-duration patterns for several types of phrases are presented.

There are two inputs and two pitch-signal extraction channels actuated by two separate microphones: one for the teacher and one for the pupil. Each channel also has an audio output for simultaneous listening to the signal while producing the vocal pattern displayed visually on the IPPI-AID screen. If simultaneous auditory and visual feedback is desired, a head-set with a boom microphone is most effective for the student.

Pitch-level adjustment knobs (5) are provided for both channels so that the student's and the teacher's intonation patterns may be moved vertically to the middle of the IPPI-AID screen for easier observation and pattern matching. When using the IPPI-AID, the teacher produces a stimulus pattern which is displayed instantaneously on the screen; the student then attempts to match his own intonation pattern to the stimulus pattern already displayed on the screen.

A mode-selector switch (6) permits the teacher to select different modes of operation with respect to pattern erasure (gradual or instantaneous after a certain display time). The features of each mode are as follows:

1. CFFT (Constantly Fading - Free to Trigger):
The voice on either channel 1 or 2 can trigger and write an intonation pattern on the oscilloscope. The pattern fades out in approximately 2 seconds so that a new pattern can be written on without interruption. This mode is intended for situations where the subject is monitoring speech continuously.



1 Intensity light

2 Intensity display switch

3 Pitch-duration display screen

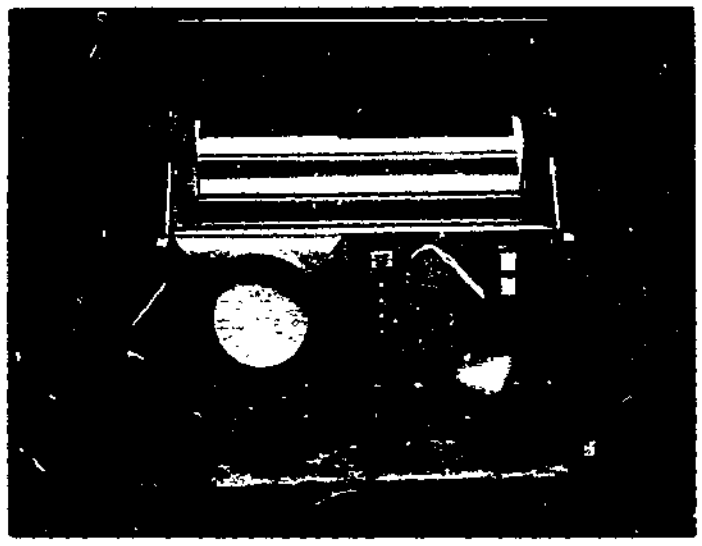
4 Pitch-display switch

5 Pitch-display level adjustment (one for each channel)

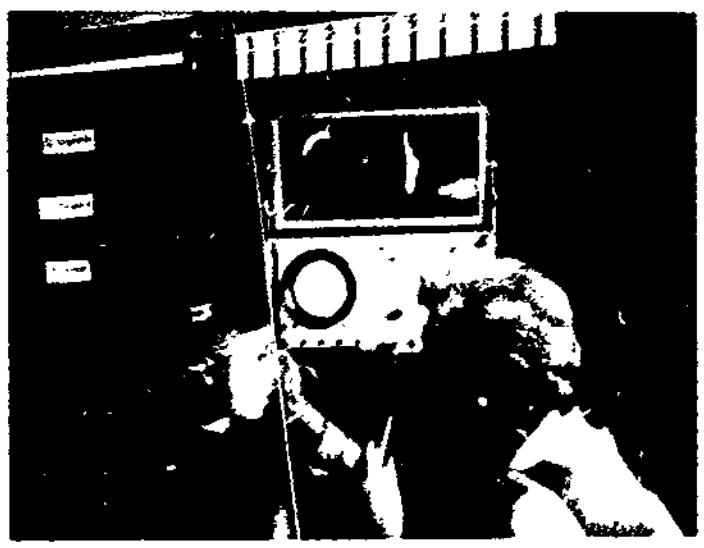
6 Mode selector switch

7 Mirror

Fig. 1. Front panel of IPPI-AID, with mirror



a. Front view with intonation patterns.



b. Instruction using the IPPI-AID.

Fig. 2. IPPI-AID with earphones and microphones.

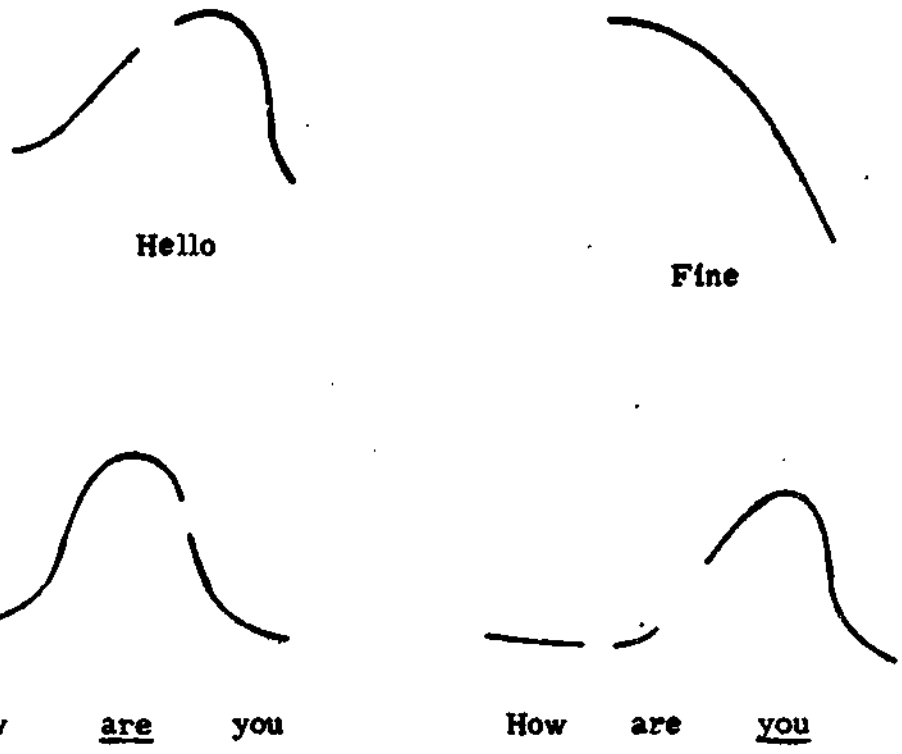


Fig. 3. Pitch-duration patterns.

2. MFFT (Minimum Fading - Free to Trigger):
The voice on either channel can trigger and write an intonation pattern on the oscilloscope. The complete pattern is stored on the screen for 4 seconds, then automatically erased. The sequence can then be repeated. This mode is useful when it is desired to display a complete-phrase or sentence pattern.

3. MFST (Minimum Fading - Sequence Trigger):
First channel 2 produces a model intonation pattern which is stored on the screen. After a two-second pause, this pattern may be matched by the intonation pattern produced by channel 1 or 2. Both patterns are stored for 4 seconds, then automatically erased. The sequence can then be repeated.

4. MFRT (Minimum Fading - Repeated Triggering):
This mode is similar to MFST except that the patterns are not automatically erased. Instead, the voice on channel 1 or 2 can continue to match the original patterns after a one-second pause. All the patterns are erased when the reset button is depressed. The sequence can then be repeated.

5. MFST (Minimum Fading - Simultaneous Display):
Either the voice on channel 1 or 2 can trigger the trace. While the trace sweeps across the screen, the voices on both channel 1 and 2 will be displayed. Both patterns are erased then the reset button is depressed. This mode is useful when the teacher and the subject practice simultaneously.

In this demonstration project, mode 4 (MFRT) was used almost exclusively. It was the easiest one for children to understand.

B. Teaching Methods

The Instantaneous Pitch-period Indicator was placed in several different classrooms of the Horace Mann School for the Deaf for periods varying from two to six weeks. In order to demonstrate the use and operation of the equipment, research teachers of the deaf served as consultants to the classroom teachers. The classroom teachers were encouraged to use speech materials used in regular classroom procedures. Use of verbal material relevant to regular lessons was encouraged. The consultants assisted the teachers in using this material in conjunction with the IPPI-AID. In classrooms used during later stages of the demonstration project. the consultants suggested revisions of classroom materials so as to incorporate selected features of the teaching materials found useful in the individualized programs.

When the IPPI-AID was being used in a classroom, both the classroom teacher and a project consultant (research teacher of the deaf) made observations of the teacher's and children's use of the equipment from a technical-operational point of view. The effectiveness of the IPPI-AID in displaying pitch patterns of classroom speech materials and the children's behavioral responses while utilizing the visual monitoring system. Observations were listed by the research teacher and summarized.

Technical problems developed with the equipment during the demonstrations. These problems were analyzed and corrected both during and after each demonstration period in a classroom. Repairs and revisions of the equipment were made in the Speech Communications Laboratories of Northeastern University.

C. Equipment Tasks

During the course of the project, a number of engineering modifications and major repairs of the equipment became necessary or at least highly desirable. For example, difficulties were encountered in connection with the tri-level indicator circuit, which is used in the T(LF)/T(HF) comparator* and in the vocal intensity display. The earphone amplifier was failing repeatedly. The failure of one of the power supplies in the main frame of the variable-persistence oscilloscope caused multiple failures in the pitch-extractor circuits. In addition, the main oscilloscope unit failed to maintain the trace on the oscilloscope screen when operating in the storage mode.

In view of these difficulties, it appeared desirable to finish the completion of a second IPPI-AID unit, so as to avoid interruption of the experiments with the deaf students by using the second unit during those times when the first unit was in repair. However, because of some very time-consuming failures of the first IPPI-AID unit, work on the second unit had to be postponed considerably; nevertheless. the second unit was finally completed.

Some effort was devoted to a preliminary exploration of the problem of a simplified, inexpensive intonation display for individual home use [6].

The work on these various engineering tasks is described in greater detail in the following sections.

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* See Ref. 2, Figs. 23 and 29b.

III. EQUIPMENT IMPLEMENTATION

A. Original IPPI-AID Unit

1. Tri-level indicator

The original design of the T(LF)/T(HF) Comparator (Tri-level Indicator)* was such that slight variations of parameters of components in the input circuit to an operational amplifier caused the output of the amplifier to drift away from its proper value. A network of diodes and resistors was attached to the inverting input of the operational amplifier and the non-inverting input was connected to the center tap of a voltage source and ground. The offset of the amplifier was adjusted by varying the potentiometer. Drifting of the dc level at the inverting input resulted in drifting of the output, which was undesirable. Periodically the offset adjustment had to be turned manually in order to compensate for the drift. This represented a quite annoying disturbance in the normal use of the equipment.

The circuit was therefore modified by making the offset adjustment a part of the input circuit to the inverting input (see Fig. 4). Thus the offset voltage at the non-inverting input tends to track the variations of dc voltage at the inverting input.

2. Vocal intensity display

The operational amplifier circuit discussed above also appears in the vocal intensity logic section of the unit.** Drift in the output of the amplifier caused improper indications of vocal intensity. In order to ensure proper operation of the intensity lights display, the same modification was incorporated into this circuit as well.

3. Earphone amplifiers

As a result of a runaway condition of the operating point, caused by the resistor-biasing network,*** the transistors in the earphone amplifiers failed quite frequently. A slight increase in quiescent current due to temperature could alter the bias so as to cause a further increase in current. As this process continued, the current soon exceeded the maximum rating of the transistor and the transistor failed. The biasing network was therefore modified as shown in Fig. 5.

4. Power-disconnecting circuit

One of the first failures of the first IPPI-AID unit was a loss of one of the several power supply voltages used in the oscilloscope main-frame. Continued attempts to use the unit with one of the voltages absent evidently resulted in the failure of several circuits in the pitch-extractor plug-in unit. In order to prevent the repetion of such a disastrous failure, a logic-controlled relay (see Fig. 6) was installed in the unit, so as to immediately disconnect the main power if any one of seven required voltages should not be present.

The inverting AND gates (G1, G2 and G3) in Fig. 6 are 12v logic gates, powered by a -12.6v supply. Thus the high state is about 0v, the low state about -12v. Main ac power will be continuously supplied to the oscilloscope only if Q1 is conducting and thus supplying current to the relay. For Q1 to conduct, the output of G3 must be low and this will occur only if each input to G3 is high. The two resistor networks connected to input terminals 1 and 2 of G3 serve to detect the absence of +100v and +250v supplies, respectively. The resistor values are chosen to present 0v to the inputs of

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* Ref. 2, Fig. 29b

** Ref. 2, Fig. 36.

*** Ref. 2, Fig. 36.

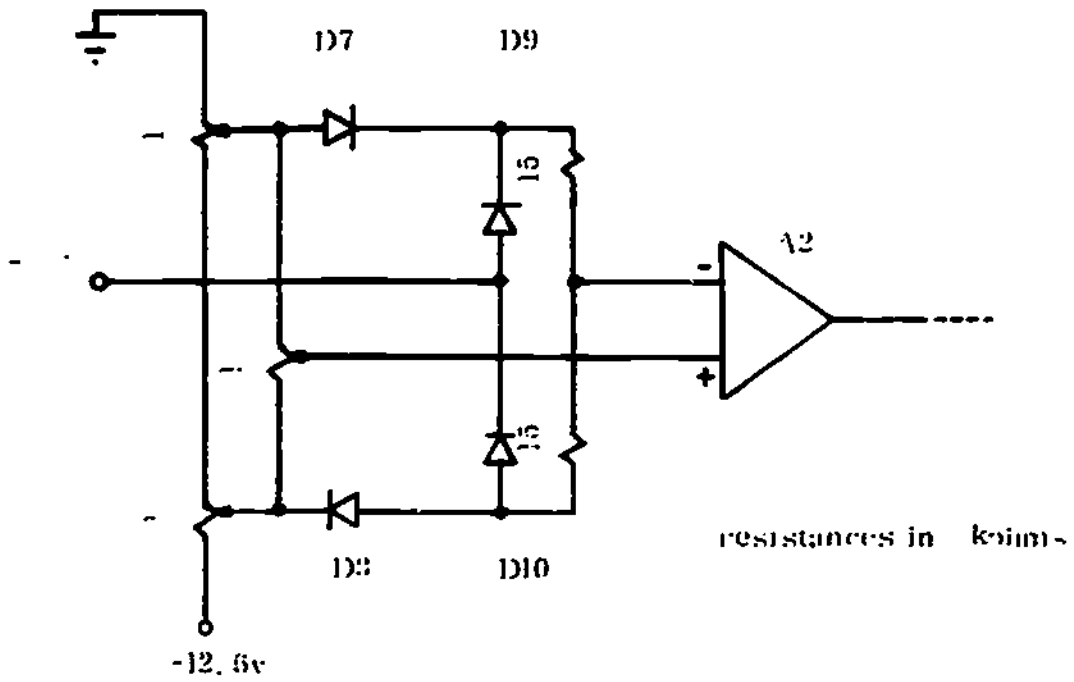

Fig. 4. Revised circuit for the tri - level indicator (see also ref. 1, p. 75. Fig. 29b).

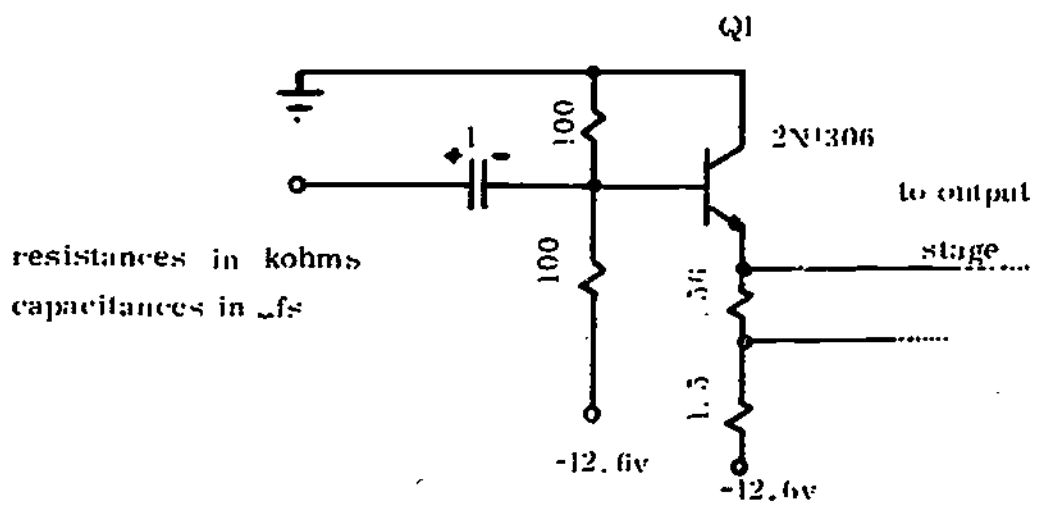

Fig. 5. Modified biasing network for earphone amplifier

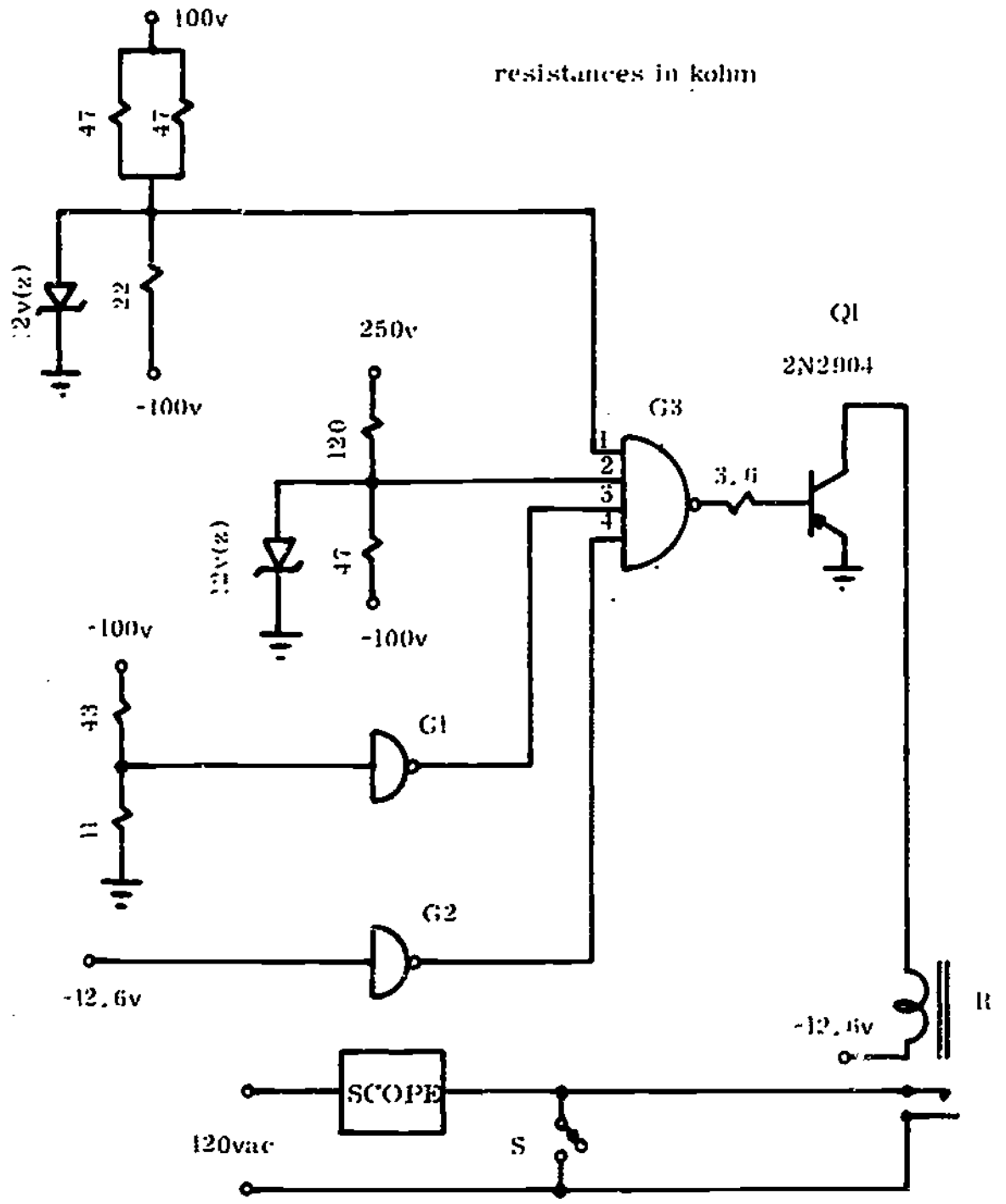

Fig. 6. Power-disconnecting circuit. Relay (R) shown in unenergized state. S is a momentary push button switch.

G3 when all voltages are present. The zener diodes are not essential to the operation of the entire circuit; they serve only as protection for the logic gates. G2 and G1 detect the absence of -12.6v from a special power supply in the plug-in unit, and -100v, respectively. The outputs of G1 and G2 will each be high when the appropriate voltages are present. Thus the loss of one or more of the +250v, +100v, -100v or -12.6v power supplies will cause at least one of the inputs to G3 to drop to -12v. This causes the output of G3 to go to its high state (0v) and Q1 is cut off, thus causing the relay contacts to open and to switch off the main power. The unit is turned on by momentarily closing switch S which shunts the relay contacts. Thereafter the continuation of main power is controlled by the simultaneous presence of all the required voltage supplies.

5. Pattern-persistence failures

The design of the metal shield around the CRT of the oscilloscope is such as to cause frequent problems with the variable-persistence function. The connection to the collimator on the storage tube which is essential to the persistence function, is accessible through a small hole in the metal shield.* The hole itself is hidden from view by a circuit board. In order to ensure a good connection to the collimator, a wire from the oscilloscope main-frame must be fastened to the terminal on the table, before the tube is pushed into its proper position. It is almost impossible to determine by visual inspection or by touch whether a good connection is made. Even if the connection is made, the insulation of the wire rubbing against the shield can fail and short the collimator to ground. This did occur in the second IPPI-AID unit. Changing the position of the collimator terminal and making a larger hole in the shield would eliminate this type of problem.

B. Second IPPI-AID Unit

Since occasional failure of any electronic equipment must be expected, it was considered desirable to complete a second, already partially constructed IPPI-AID unit. However, this work had to be postponed whenever more urgent tasks, such as e.g. the catastrophic failure described in Section III-A-4, needed immediate attention. Thus it proved necessary to postpone the ultimate completion considerably.

The actual task of completing the second unit consisted of the following items:

(a) Minor redesign of the sequencing circuits, to improve the reliability of visual presentation.

(b) After the determination of the final circuit configuration, etching of the final circuit board containing the sequencing circuits.

(c) Wiring of the circuit board.

(d) Testing of the circuit board.

(e) Testing of several other untested boards.

(f) Wiring of the main-frame of the plug-in unit, which holds the printed-circuit boards of the pitch indicator.

(g) Investigation of the causes of a drift problem, apparently occurring in the main part of the storage oscilloscope.

(h) Procurement of a mirror, to be mounted on top of the IPPI-AID, for visual communication between the teacher and the student.

(i) Construction of an additional cover of the storage oscilloscope, in order to conceal a number of control knobs, and thus prevent undesired manipulation of these controls by students.

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*Ref. 7, 4-3.

a. Single stored pattern

b. Two patterns stored simultaneously

Fig. 7. Intonation patterns stored on the electroluminiscent image-retaining paper.

(j) Incorporation of any circuit changes which were found to be desirable in the course of the work with the first IPPI-AID unit.

(h) Overall performance test of the completed second IPPI-AID unit.

All the above items have been completed; however, additional testing for reliability would be desirable.

C. Personal Intonation Display.

An investigation was made into the possibility of a more economical pitch-display device that could be used by the deaf individuals at home.* One possibility for such a device is a display based on an image-retaining electroluminescent panel developed by G.T. & E.-Sylvania. When the proper voltage is applied to the panel, a pattern may be written on the surface of the panel by moving a fairly intense light beam across the panel, In darkened surroundings, illumination appears along the path of the light beam and remains for a few minutes, or until it is erased by changing the holding voltage mentioned above. Several patterns may be similarly stored at the same time. In order to evaluate the panel's ability to display and store pitch-inflection patterns, an experimental device was constructed. Details of design and discussion of operation of the model may be found in ref. 2.

The use of such a panel in a pitch-display device would eliminate a major part of the cost of the present IPPI-AID. Although other mechanisms must provide control over a moving light beam, the panel essentially performs the same function as a storage tube in a storage oscilloscope at a small fraction of its cost,**

Samples of patterns produced by the experimental model mentioned above and retained on the panel are presented in Fig. 7. Figure 7a shows one stored intonation pattern, while Fig. 7b represents two simultaneously stored intonation patterns. Thus while further refinements of the personal pitch display would appear desirable, it has been definitely shown that the image-retaining panel could serve as a simple means for intonation-pattern storage.

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* The cost of the storage-oscilloscope part limits the use of the IPPI-AID to institutions (schools, rehabilitation centers, etc.).

** The panel is as yet not commercially available; it is estimated that a 3"x3" image-retaining panel would eventually cost around $20,

IV. RESULTS

A. Demonstration 1: Middle-School Classroom

The IPPI-AID was first used in a middle-school classroom of the school for the deaf for two months. In preparations for the demonstration project, and in order to select materials for use with the equipment, the research teacher of the deaf spent several days observing classroom activities. The equipment was also demonstrated to the classroom teacher.

The IPPI-AID was used with two groups of 12-13 year old children who were in the classroom for portions of each day (departmental teaching). Eleven children had profound hearing losses. Eight of them were familar with the operation of the IPPI-AID from experience in a previous research project [1].

As a preliminary step in the training program, the research teacher tested each child's ability to perceive a series of segmented lines as components of one pattern. This ability was considered necessary for the learning and reinforcement of the visual displays of intonation patterns. All of the children completed the tasks satisfactorily.

The research teacher demonstrated the equipment to each child individually in a sound booth outside the classroom. In an attempt to conduct this aspect of the program in the classroom, it was found that the triggering threshold of the IPPI-AID was too low to prevent spurious visual displays due to normal classroom back-ground noise. As part of the demonstration, the children were permitted to produce spontaneous vocalizations so as to familiarize themselves initially with the idea that their vocalizations were responsible for the changes in the visual display. In addition, the research teacher structured several verbal responses by the children in each of the various modes of the IPPI-AID.

The classroom teacher experimented with the IPPI-AID, using it to teach the intonation patterns of common idiomatic expressions. She found, however, that due to the prevalence of unvoiced sounds in these expressions, it was not possible to produce meaningful intonation patterns. Consequently, the teacher decided to incorporate the IPPI-AID into formal language lessons, where she could select expressions which contained a predominance of voiced sounds. The classroom language unit dealt with the recognition, simulation, and interpretation of various emotions, both vocally and facially expressed. The children were asked to respond to emotionally-laden pictures, each of which was designated by an appropriate verbal expression. Each expression was associated with a different visual pattern. The children observed their vocal patterns on the IPPI-AID. The teacher worked with each child individually, in turn, while the others observed.

In preparation for the lesson, the teacher spoke each expression included in the formal lesson, observed the patterns on the IPPI-AID screen, and drew the patterns on a flash card to be used as a stimulus model by the students the next day. Then the visual feedback of the IPPI-AID indicated a child's success or failure in reproducing the pattern. When a child failed to produce the correct pattern the teacher introduced various rhythm and pitch exercises, involving nonsense syllables, which the teacher believed would help the child in producing the original pattern. She vocalized each practice pattern and the children observed the IPPI-AID screen. The pupil then attempted to match the teacher's pattern.

The classroom and research teachers' ohservations and impressions during the demonstration period were:

(1) The IPPI-AID has good potential as an educational tool.

(2) Technical malfunctions and instability of patterns, requiring removal for repairs, interfered with continuous use of equipment in this classroom demonstration and caused frustration on the part of the teachers.

(3) Background and extraneous noises often triggered the pitch display, causing spurious patterns, and indicating the need to adjust the sensitivity of the triggering circuits as well as the need to use classrooms with good acoustical treatment.

(4) Use of spontaneous classroom speech did not prove feasible because of the large number of unvoiced sounds used. The IPPI-AID is more effective when the verbal material contains vowels and voiced consonants and a continuous flow of phonation in a spoken work or phrase.

(5) During this demonstration, the IPPI-AID seemed more effective for individual rather than group work. However, the teachers concluded that the individual work should be done separately rather than as part of group usage of the equipment, as other children became bored if too much time was spent on drill work with one child.

B. Demonstration 2: Nursery Classroom.

The IPPI-AID was used with 12 children, 4 and 5 years of age, enrolled in two nursery-level classes. These classes have a nursery teacher and a teacher of the deaf who work with the children. The teacher of the deaf works in the nursery classroom with groups as well as with individuals in a separate tutoring room. From previous experience, the research concluded that the work with the IPPI-AID in this demonstration should begin on an individual basis in the tutoring room.

The speech tutor designed a series of lesson plans which dealt with a variety of pitch tasks ranging from the vocalization of nonsense syllables in rhythm patterns to the vocalization of words with inflection. Objects and pictures were used to elicit the desired responses from the children. The tutor, with the assistance of the research teacher, attempted to use the unit with each child at least twice a week for about 10 minutes each time. During the initial session with each child, the teacher demonstrated the use of the IPPI-AID. In order to satisfy the curiosity of the children they were permitted to manipulate the knobs and dials on the front of the machine. During each successive session, new materials were introduced. The lessons were concerned with encouraging vocalization, controlling the duration and intensity of vocalizations, and developing the ability to produce and words at various pitch levels. Many of the lessons were adapted from the formal teaching program used in previous research experiments [2]. The following is a sample of the lessons:

1. Objective: To encourage vocalization
   Materials and Activities:
   a. animal sounds made by dog, sheep, cat, cow.
   b. sounds made by train, plane, car.
   c. telephone conversation.
   d. verbal response to pictures evoking emotions.

2. Objective: To produce sounds of long and short duration.
   Materials and Activities:
   a. sustained vocalization of sounds.
   b. vocalization of nonsense syllables in various rhythm patterns.
   c. association of sounds of long and short duration with long and short objects.

3. Objective: To produce sounds of loud and soft intensity.
Materials and Activities:

   a. association of loud and soft sounds with small and large objects.
   b. association of loud and soft sounds with intensity lights.

4. Objective: To produce sounds and words at various pitch levels
Materials and Activities:

   a. association of high- and low-pitched sounds with high and low objects.
   b. vocalization of nonsense syllables and words in various pitch and intonation patterns.

The teacher introduced an object or picture which was designed to stimulate a desired vocal response. The teacher produced the vocal response and indicated the visual pattern on the IPPI-AID to the child. The child then attempted to match the teacher's pattern. If a child did not appear to understand the connection between the teacher's vocalization and the visual pattern on the IPPI-AID, the teacher used tactile cues, e.g. the child's hand on the teacher's throat, or the presence of a hand microphone in order to convey the connection. If a child did not appear interested in working with the IPPI-AID, the teacher attempted to interest the child with candy or a favorite toy. When a child made a correct response or exerted the effort to make a correct response, he was rewarded with the teacher's praise and candy or some other prize. A child remained with the IPPI-AID until he appeared to lose interest in it.

Initially, all the children were excited by the visual patterns produced by the teacher. Seven of the children were eager to produce their own visual displays and vocalized spontaneously. The others either did not desire to wear the headphones, were not motivated to vocalize themselves, or vocalized in too weak an intensity to trigger a visual display. All of the children were fascinated with the knobs, and lights and dials. During subsequent lessons some children became interested more in the lights and dials than in the visual displays. As the lessons progressed it became increasingly difficult to see each child as frequently as was desired. Also, there was variation in the interests of children in coming to the tutoring room. Some preferred to remain in the group play activities of the nursery classroom.

The research teacher and the tutor decided to determine whether group participation would increase the interest of those children who had not responded well.

An entire class was invited into the tutoring room. Each child was given an opportunity to work with the IPPI-AID while others observed. All children were eager for their turns. They appeared anxious to impress each other with their vocal patterns on the IPPI-AID screen. One child who had refused to wear earphones permitted them to be placed on her after seeing other children wear them. One child vocalized spontaneously and produced a visual display for the first time. Two other children produced spontaneous intonation patterns for the first time. By the end of this demonstration phase all the children had learned to match the teacher's visual display of the sustained vowel sound "ah" and the repeated unstressed syllable "bu." None of the children learned to match the rising and falling inflection patterns produced by the teacher. Five children, however, produced spontaneous inflection patterns. The impressions of the classroom and research teachers were:

1. The children sometimes appeared confused about where to focus their attention on the machine. Their attention would wander from the visual pitch-displays to one or more of the following distractions: the teacher, the mirror, the intensity lights, the lights on the various control buttons.

2. Some children became so absorbed with the pictures and objects used to stimulate their vocalizations that they ignored the IPPI-AID altogether.

3. The microphone attached to the headset did not appear to convey the connection between the child's vocalizations and the visual displays on the IPPI-AID. It was felt that a hand microphone placed in front of the child might have been more effective in establishing this connection.

4. Tactile cues, e.g. when the child placed his hand on the teacher's throat while she vocalized, enabled many children to realize the connection between their vocalizations and the visual displays on the oscilloscope screen.

5. Manipulation of the dials and knobs on the unit sometimes resulted in a machine malfunction.

6. While eight children vocalized with intensity to trigger the pitch displays from the beginning, the others learned gradually to vocalize with sufficient intensity. Two children strained their voices in order to produce a pattern.

7. The intensity lights enabled all the children to distinguish between their own loud and soft vocalizations.

8. The children had too small a speech vocabulary for the teacher to use in teaching inflection and intonation patterns.

C. Demonstration 3: Middle-School Classroom.

Following the summer and fall during which repairs and circuit repairs were made on the IPPI-AID, the equipment was placed with the same middle-school teacher who had used it previously. The classroom teacher used the equipment herself with a new group of pupils who were unfamiliar with it. She used it as an adjunct to her regular classroom program in speech development. Teaching sessions were observed periodically by the consultant research teacher of the deaf.

One aspect of the teacher's program involved the teaching of intensity levels, using the intensity leights of the IPPI-AID. She began by teaching the difference between whisper and voice; whisper would light one light, voice would light two or three lights. She then taught differences between normal and loud intensity levels. The students responded well to this teaching approach and learned the concepts of whisper, normal and loud volume levels.

In preparation for teaching rhythm patterns of speech, the teacher used flash cards with short sentences in different rhythms. On the flash cards, she drew the lines that would appear on the IPPI-AID scope when it was used later. She explained the concept of rhythm using the sentence flash cards to illustrate different rhythm patterns. She also engaged the class in group practice with nonsense syllables and the rhythm patterns on flash cards. When she felt the students understood the concept of rhythm in speech, she used the IPPI-AID to permit the students to monitor their own spoken rhythm patterns.

The IPPI-AID provided a self-monitoring, corrective function for the students' own speech. It represented an excellent motivation device which also aided the student in self-correction. Students responded enthusiastically, taking turns and discussing each other's speech patterns as displayed on the IPPI-AID screen. While concentrating on rhythm patterns the students also produced pitch changes which were displayed as intonation patterns on the IPPI-AID screen. Refinements of intonation patterns were not included in the demonstration, but the teacher expressed a desire to have the equipment again so she could teach intonation patterns of different vocal expressions. The students were excited about the equipment and responded well to it. Since the teacher did not spend long periods on individual corrective work, but allowed the students to take turns for short practice periods, interest remained high throughout the demonstration project.

D. Demonstration 4: Upper-School Classroom

The IPPI-AID was used daily in a classroom of six 14-17 year old deaf boys by a male teacher and a consultant research teacher. The boys were very sports-minded and most had been playing on the school basketball team. The consultant research teacher started with a demonstration lesson at the beginning of each week and the classroom teacher continued the lessons for the remainder of the week.

The first week was devoted to basketball expressions which would be displayed on the IPPI-AID screen as combined rhythm-intonation patterns. Expressions were selected for both single-word inflections, such as "shoot," "score," "foul," and phrases, "jumpball," "come on shoot," "over here." The students sat in a semi-circle facing the IPPI-AID screen. The teacher used a hand-held microphone with a long cord and passed it from student to student. After the teacher's model pattern of an expression was displayed on the storage screen each boy, in turn, spoke the same expression. The trials of all six boys were allowed to remain on the screen as they were produced in succession. All boys needed a few trials with each expression. However, during a half-hour session daily for a week, five boys succeeded in producing good rhythm and intonation patterns. One boy, with an extremely high-pitched voice, who has not been very oral in school, was unable to match the patterns in either rhythm or intonation. It was concluded that he would require long-term individual instruction with the program used in previous research [2]. It was also observed that some of the expressions chosen for the demonstration had several unvoiced consonants, which made the pitch-displays more sporadic and difficult to duplicate.

During the second week, the topic of baseball was used. The voice of an umpire calling balls and strikes uses sustained phonations with varying pitch which would display clear patterns on the IPPI-AID screen. The sequence used to create interest was:

Ball one
Ball two
Strike one
Ball three
Strike two
Strike three
You're out.

All boys succeeded in producing the patterns demonstrated by the teachers. The boy with the high-pitched voice was able to sustain the words with the proper duration and rhythm even though his pattern was displayed at a high level on the screen. Except for this boy, it was observed that the vocal quality of the students was good when producing the vocal expressions with the appropriate duration, rhythm and intonations, after a few sessions of practice. The combination of the topics used for the vocal expressions and the instantaneous feedback and self-monitoring provided by the IPPI-AID oscilloscope displays served as a good means of motivation, and resulted in better vocal patterns with the practice materials used in the demonstration.

E. Demonstration 5: Lower-School Classroom

The IPPI-AID was placed for two weeks in a lower-school classroom of five six year old children. For the first two days, the consultant research teacher demonstrated the equipment during the class speech lesson with material selected by the classroom teacher. The teacher was interested in increasing vocalization as only two of the five children used much speech. The teacher chose to use sustained vowels and the consonant "m."

Using the oscilloscope screen at first, the children did not always use sufficient vocal intensity to trigger the intonation display line. If they did, they did not sustain the duration sufficiently to match the teacher's model pattern. Therefore the pitch display was turned off and the intensity display was turned on. The children were shown how to vocalize to light two or three intensity lights. Within a twenty-minute practice session, all five children could vocalize a vowel with sufficient intensity to trigger three intensity lights. The consultant research teacher then shifted from the intensity lights to the pitch display of the IPPI-AID. All children were able to produce a pitch line on the screen, although the duration was short, compared to the teacher's model pattern.

The third day the teacher continued with the pitch display, using sustained vowels and the consonant "m." She included pitch inflections expressing enjoyment of food- ice cream, candy, etc. The children were all able to sustain phonation for the full 2-second display that is possible on the IPPI-AID screen although they did not always vary the pitch of their phonations.

For the remainder of the demonstration period the teacher used short-sentence expressions from her news and language lessons. The children continued to produce longer phrases of speech with more sustained phonations. Some began to vary pitch during the expression although they did not attain skill in matching the intonation patterns of the teacher's model patterns.

The teacher reported that all the children used much more vocalization during the lessons using the IPPI-AID as an adjunct to teaching than they had used in previous speech-language lessons.

F. Demonstration 6: Miscellaneous Teacher Experimentation

The consultant research teacher demonstrated the equipment briefly to other teachers.

In one classroom of six severly hard-of-hearing boys, the teacher had completed an informal discussion session on topics of interest to the boys, and had developed new vocabulary words and some mathematical concepts of prediction. The consultant research teacher had observed the lesson and attempted to select from the classroom material used speech expressions that might be appropriate for IPPI-AID displays. When he attempted to use these expressions with the boys and the IPPI-AID, he found that the expressions, with many unvoiced consonants and rapid speech rhythms did not produce readily identifiable patterns. The boys were quite oral students with considerable usable hearing. It was not possible to interest them in the IPPI-AID in this session. It was evident that more careful planning of appropriate language would be required to obtain IPPI-AID patterns that would interest these boys in improving their speech.

The upper-school teacher who teaches language, reading and speech to several groups of students experimented herself with the IPPI-AID. The need for using expressions with few unvoiced consonants and more sustained phonations was explained to her. The teacher then selected several phrases from her daily lessons and spoke them into the IPPI-AID microphone. The displays were clear, and differentiated the intonation patterns for changing meanings. The teacher concluded that she could use the IPPI-AID as an adjunct to her teaching of rhythm and intonation of spoken language and oral reading.

The Horace Mann School for the Deaf expects to adopt the psycho-linguistics approach to language teaching developed by Blackwell and Hamel [1] for the Rhode Island School for the Deaf. This language curriculum uses five different sentence

(syntactical) patterns based on the principles of transformational grammar. The consultant research teacher and a Horace Mann School teacher spoke the different sentences and observed the displays on the IPPI-AID screen. When the sentences were spoken with no more than the 2-second display duration of which the IPPI-AID is currently capable, the intonation displays were distinguishable for the different syntactical patterns. As an example, the intonation curves for sentence pattern one "The wind blew," and sentence pattern two "The wind blew the leaves," are shown in Fig. 3.

V. CONCLUSIONS

The IPPI-AID was used in several classrooms in a school for the deaf to determine its appropriateness as an adjunct to classroom instruction with classroom speech/language materials. The effectiveness of the IPPI-AID for individual instruction on rhythm and intonation patterns of spoken language had been demonstrated in previous research studies [2, 3, 4]. The following conclusions can be drawn from the demonstrations in classroom (group) instruction:

1. The IPPI-AID serves to motivate deaf children to increase both the quantity and variety of their vocalizations in the classroom. This conclusion applies to all class levels from nursery (pre-school) to upper school.

2. Teachers who plan specific speech/language lessons were able to learn to use the equipment with their own class after demonstration by a research teacher of the deaf. Teachers who had the equipment in their classrooms for six weeks devised more varied uses than those who had the equipment for only two weeks.

3. The children responded best to the intensity-lights displays and to the duration and rhythm aspects of the lines of the pitch-indication oscilloscope display. Less success was experienced with intonation patterns during the particular demonstrations attempted.

4. Spoken language which developed spontaneously during class lessons frequently contained so many unvoiced consonants and brief pauses that the displays consisted of broken lines and lack of identifiable rhythm or intonation patterns. Spontaneous language does not appear suitable for use of the IPPI-AID. Planned language lessons with spoken expressions containing mostly prolonged vowels and voiced consonants are more suitable.

5. Sometimes a pupil would have difficulty with a particular spoken language task, compared to other children in the group. Attempts to provide individual corrective instruction during a group lesson was not very successful. Prolonged individual instruction resulted in loss of interest by the rest of the group, and tended to produce frustration on the part of the individual child. Separate individualized instruction at another time is indicated for such a child.

6. A hand-held microphone, with a long cord permitting several pupils to take brief turns, was more effective in the group situation than the head-set microphone designed for individual instruction. The lack of instantaneous auditory feedback from the IPPI-AID was replaced by the use of the child's own aid and did not seem to deter the children's responses.

7. MFRT* was the most useful mode; this mode permits the teacher to speak a model pattern which is displayed on the IPPI-AID screen, and allows several children's patterns to be stored on the same screen for simultaneous comparisons.

8. The equipment required some circuit redesigns and is still susceptible to occasional minor malfunctions which require adjustments by the design engineers. These malfunctions caused frustration on the part of teachers using the equipment in their classrooms.

9. The audio gain for the head sets is insufficient for profoundly deaf children with residual hearing in the low frequencies.

10. An alternative method of intonation-pattern storage, using an electroluminscent image-retaining panel was demonstrated to be feasible [6]. While requiring darkened surroundings for its operation, the use of the image-retaining panel would reduce the equipment cost by a large factor.

*Minimal Fading-Repeated Triggering

VI. RECOMMENDATIONS

The results of this demonstration project, combined with the previous experience of this research staff with the Instantaneous Pitch-Period Indicator and the Voice Visualizer, suggest the following recommendations:

1. A program using visual oscilloscope displays of parameters of speech should provide for both group classroom use and separate individualized instruction according to the specific needs of each child.

2. A teacher's manual should be developed with illustrative lessons and topics, using spoken language vocabularies and syntax which are most appropriate for discernible displays of rhythm and intonation patterns. Training sessions in the use of the equipment and materials should be provided for each teacher in her own classroom. Examples of the different syntactical sentence patterns of the psycho-linguistic approaches to teaching language, which are being used more and more in schools for the deaf should be included in the illustrative lessons.

3. Future models of the IPPI-AID should be constructed with certain design modifications to increase efficiency and flexibility of use, and to simplify the construction of the equipment. These modifications are:

a. Elimination of the different operational modes, using a modification of the MFRT mode, permitting any number of consecutive displays by either the teacher or the student.

b. Relocation of the intensity lights to the right side of the front panel so as to eliminate confusion of children in viewing the lights.

c. Relocation of all controls into the center of the panel, with a hinged cover, to remove the distraction of the control knobs from the children's view.

d. Redesign of the headset amplifier circuit to provide more audio gain. This audio amplifier is only required for the student's microphone; the teacher does not need a head set.

e. Both a head set-microphone combination and a hand-held microphone should be provided with a unit.

f. The polar analyzer circuit of the Voice Visualizer [5] should be incorporated into a redesigned unit to permit display of vowel and consonant sounds for articulation training.

g. A new admustment should be provided which will permit displays up to 3 seconds in duration on the IPPI-AID screen, in order to accomodate syntactically more complex sentence patterns.

4. In order to make an IPPI-AID type display generally available for individual (home) use, research efforts should be continued along the direction of ref. 6, which demonstrated one possible alternative of storing inexpensively intonation patterns without the use of the variable-persistence oscilloscope which, because of cost, limits the IPPI-AID to institutional use.

5. Research should be conducted using the Instantaneous Pitch-Period Indicator and the Voice Visualizer as a combined visual-display self-monitoring system. Such research could determine the effectiveness of a training program which permits individual instruction in vocal patterns (rhythm and intonation) and articulation of speech sounds. The results of previous research suggest that to ensure improvement of speech intelligibility, training in all aspects of spoken language is necessary.

VII. PRESENTATIONS

1. N.D. Phillips, Demonstration of IPPI during Massachusetts Creative Education Fair, Boston (1969).

2. Scientific exhibit in connection with the Meeting of the Speech and Hearing Association, Chicago, Ill., 12-15 November, 1969. (This exhibit resulted in 1000 requests for further information on the demonstrated IPPI-AID).

3. N.D. Phillips, Seminar on the IPPI-AID for the Department of Special Education, Northeastern University, Winter 1969-1970.

4. L. Dolanský, N.D. Phillips, S.D. Bass, W.L. Pronovost, D.C. Anderson, "An Intonation Display System for the Deaf," Scientific Symposium on Speech Communication and Profound Deafness, 12-14 August, 1970, Stockholm, Sweden, (invited paper).

5. W.L. Pronovost, presentation for the panel on "Education Media Visual Approaches," International Congress on Education of the Deaf, Stockholm, Sweden, 17-21 August 1970.

6. L. Dolanský, "IPPI-AID and Intonation-display Problems." Seminar presented at the National Technical Institute for the Deaf, Rochester, N.Y., 7 April 1971.

7. L. Dolanský, Demonstration of the IPPI-AID for interested students and teachers of the Weston High School, Weston, Massachusetts, 28 April 1971.

VIII. PUBLICATIONS

1. W. L. Pronovost, "The Instantaneous Pitch-period Indicator," AOEHI (American Organization for the Education of the Hearing Impaired) Bulletin, pp. HI 37-39, Spring 1970.

2. L. Dolanský, N. D. Phillips, S. D. Bass, W. L. Pronovost, D. C. Anderson, "An Intonation Display System for the Deaf," to be published in Acustica, vol. 25, No. 4 (1971).

3. C. J. Savage, Visual Pitch Display for the Deaf, MS Thesis, Department of Electrical Engineering, Northeastern University, May 1971.

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3. Dolanský, L., Ferullo, R.J., O'Donnell, M.C., Phillips, N.D., Teaching of Intonation and Inflections to the Deaf, Final Report, Cooperative Research Project No. S-281, Northeastern University, Boston, Mass., (1965).

4. Dolanský, L., Karis, C., Phillips, N., Pronovost, W., Teaching Vocal Pitch Patterns Using Visual Feedback from the Instantaneous Pitch-period Indicator for Self-monitoring, Final Report, Part I, VRA Project No. 1907-S, Northeastern University, Boston, Mass., (31 October 1966).

5. Pronovost, W., Anderson, D., Lerner, R., Yenkin, L., The Development and Evaluation of Procedures for Using the Voice Visualizer as an Aid in Teaching Speech to the Deaf, U.S.O.E. Final Report, Project No. 6-2017, Boston University (31 August 1967).

6. Savage, C.J., Visual Pitch Display for the Deaf, MS Thesis, Department of Electrical Engineering, Northeastern University, (May 1971).

7. Anonym. Operating and Service Manual, Model 141A Oscilloscope, Hewlett-Packard Co., Colorado Springs, Colorado (1967).